ENDANGERED AND THREATENED PLANTS OF UTAH: A CASE STUDY

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Abstract.— Endangered and threatened plants of Utah are evaluated as to their distribution in phytogeographic subdivisions, substrates, plant communities, elevations, and geological strata. The phytogeographic subunits were partitioned and comparisons made of distribution as outlined for the parameters cited above. A predictive model is suggested based on the nonrandom distribution of endemic plant species.

The Endangered Species Act of 1973, Public Law 93-205 (as ammended 1978), was an outgrowth of decades of concern regarding the future of that portion of our heritage of living things, which, by the nature of their distributional patterns, could most easily be eradicated as man pressed to exploit the resources of the earth, both finite and renewable. The act dictated an orderly process for development of lists of endangered and threatened species, defined terminology, and provided for development of criteria for determining candidate species.

Plants are the mantle of the land, nourishers of life's feast, holders of soil, suppliers of construction materials, of medicines, and of other substances too numerable to mention. They provide the basis of all life on earth, save some few living things which are capable of chemosynthetic utilization of energy. This fact and the list of materials that flows from plants need not be mentioned. Yet, the spread of mankind over the face of the earth, his development of agriculture, and, more especially perhaps, his development and spread of an industrial society with its great demands on space and materials has resulted in a direct competition for the space that was, or is, occupied by the indigenous flora of the earth.

The clearing of agricultural land for planting of crop plants, as selected from that indigenous genetic stock available as portions of the total flora, was possibly the beginning of the role of mankind as a major agent for reduction of plant species. Even those from which the crop plants were developed were not spared from destruction or modification.

Agriculture is, nevertheless, a more efficient means for the production of biological materials that can be consumed by man and by his livestock than from the previously employed methods of gathering and hunting.

Industrialization merely speeded the process by which agricultural lands could be cleared of native plants and those lands then maintained in single crop cultures. With industrialization came the explosion of demands for resources of many kinds: ferrous and nonferrous metals, chemical compounds of all kinds, sand and gravel, coal and oil, uranium, and other naturally occurring materials.

The mantle of the land gave way as each new source was discovered. Roads were cut through the vegetation. Quarries, open pit mines, portals, corridors, industrial plant sites, pipelines, villages, towns, cities, garbage dumps, litter, and other features of civilization were placed atop the shrinking vegetation.

Into the vast array of plant species marched also an infinitesimally small cadre of

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persons determined to know about the plants themselves—to name them, to describe them, to plot where they grew, and to recognize that there is an intrinsic value in each plant species, no matter how insignificant it might be considered. Botanists they were called, whether by training or by inclination they arrived at a point where plants become their pursuit. At first, all botanists were taxonomists. Later, not even all taxonomists were taxonomists.

Late in the human story the taxonomists began to catalogue the vegetation of the earth. Systematic surveys of vegetation and collections of plant species began in earnest only in the eighteenth century, in North America not until the nineteenth century, and in Utah the main thrust did not come until the twentieth century.

By the beginning of the third decade of the present century, the common plant species and their general areas of growth were well known. The work of the various government surveys and of pioneer botanists had penetrated even to some of the most remote regions of western North America. Discovered were some of the most rare of species, but others remained undiscovered.

Cognizant of the increasing demands of a growing population and an expanding civilization, botanists, always too few for the task, were hard pressed to survey all of the remote regions in a systematic manner. Collections were taken in a haphazard way. A trip to the hot desert in springtime, another to the cool mountains in midsummer, and by autumn the enthusiasm for collecting was cut short, too often by the need for gainful employment—because botanists could seldom be gainfully employed as botanists.

As the search areas narrowed, and as collections were taken in a more systematic manner, the number of known narrowly restricted plants increased proportionally. A still finer search may yet yield many additional narrowly adapted endemics. They are plants of all elevational ranges, but they are most common in highly specialized habitats, those which are likely to be occupied by other narrowly restricted plants also.

Often the species belong to difficult or to purportedly difficult taxonomic groups, such as *Astragalus*, *Eriogonum*, *Erigeron*, and others. Few people have taken the time to understand these complex assemblages, or to even collect and attempt to identify them. Fortunately, monographers have examined many of the problem genera and have clarified the nature of taxonomic limits, often on the basis of very limited materials.

Passages of the Endangered Species Act found botanists in most regions of the United States ill prepared to provide definitive information regarding candidate plant taxa, which had been included in the act mainly as an afterthought. Despite the lack of specific information, the act called for the secretary of the Smithsonian Institution in Washington, D.C., to report to Congress within one year on all of the "species of plants which are now or may become endangered or threatened" in the United States (Section 12, Public Law 23-205). In December 1974, the secretary of the Smithsonian Institution, S. Dillon Ripley, submitted a "Report on Endangered and Threatened Plant Species of the United States" to Congress.

That report formed the basis of the 1 July 1975 Federal Register (Vol. 40, No. 124: 27824–27924), which contained a review of the endangered and threatened plant species. The number of species assigned to those categories for the twelve western states (exclusive of Hawaii) is presented in Table 1. That pre-

TABLE 1. Number of species reviewed as endangered and threatened in 1975 and proposed as endangered in 1976, in twelve western states.

	Date		
	1975 Status		1976 Status
STATE	E	T	E
Alaska	9	21	6
Arizona	65	106	66
California	236	412	286
Colorado	23	17	32
Idaho	21	41	21
Montana	2	8	3
Nevada	43	84	50
New Mexico	15	26	20
Oregon	43	135	51
Utah	56	101	66
Washington	16	72	18
Wyoming	3	18	8
Total	582	1041	627
Grant total = 1623			

liminary list of 1975 was based on the best information available to scientists at the Smithsonian Institution working in collaboration with those from the Department of the Interior. The lists were reviewed by selected specialists and botanists at a workshop held at the Smithsonian in September 1974.

That the 1975 lists were preliminary is to be found in the differences in numbers of endangered species published in the Federal Register (Vol. 41, No. 117: 24524–24572) published on 16 June 1976 (Table. 1). Even in such states as California, with its formidable number of qualified professional taxonomists and amateurs, the number of endangered plant candidates increased significantly between 1975 and 1976. No such comparable list is available for candidate threatened plants, but some of the increase in endangered species is represented in change of status from threatened to endangered (Kartesz and Kartesz 1977).

Impetus for acquisition of knowledge of rare plant species was generated by the lists of 1975 and 1976, and by the policy of active search for information required by governmental agencies, which was built into the act. Funds were forthcoming from various federal agencies to make determinations of range, habitat, condition, impacts, and potential impacts, and for other information on the candidate species. Rule making was entered into by the U.S. Fish and Wildlife Service, Department of the Interior, and, at present, some 20 species of plants have been determined as endangered or threatened. Two of these, *Astragalus perianus* Barneby and *Phacelia argillacea* Atwood, are from Utah (see Federal Registers Vol. 40, No. 81: 17910–17916, and Vols. 43, No. 189: 44810–44812, respectively). The former is listed as threatened, and the latter is listed as endangered.

Impacts of the act have been widespread. It has been subjected to political and emotional, as well as to scientific, evaluations. The act has been modified to some extent as a result, but those evaluations are not the basis of this contribution. Rather, I intend to pursue the developmental basis of information dealing with endangered and threatened species, and to outline one basis of the nature of those critical plants.

Biology of Endangered and Threatened Species

The biology of endangered and threatened species in Utah is, with few exceptions, the biology of narrowly restricted endemics. Therein lies the basis for disparity between lists and category representations. The amount and quality of botanical knowledge of common species is seldom sufficient to allow more than generalizations; that for rare species is likely to be lacking altogether. The task of surveying vast areas for narrowly restricting plants is a huge one, carried out in the past largely by individuals with much devotion and little financing.

Too, the fact that a plant is an endemic and is rare has often been considered as evidence of endangerment. Lists are replete with such examples, but studies have indicated that rare plants might not be endangered or threatened, and that plants thought to be rare were in fact relatively common and widely distributed. For a plant to be a candidate for inclusion on final lists of endangered and threatened plant species, it must have endangerment, both quality and quantity, clearly demonstrated.

Contemporary studies are under way to aid the Department of the Interior with decisions necessary for final rule making. Studies of distribution, population numbers, degrees of endangerment, and many other facets are being undertaken, which will lead to development of information summaries of all species which have been reviewed, proposed, or recommended.

Much information has already been gleaned from the specimens extant in herbaria. For the purpose of this paper, endangered and threatened plant species from Utah will be used to illustrate the contemporary knowledge of status of those species, and to provide the model for a case study of the nature of those species.

A list of endemic and rare plants of Utah was prepared by Welsh, Atwood, and Reveal (1975). In that publication, some 382 vascular plant taxa were considered, with 66 regarded as endangered, 198 as threatened, 7 extinct, and 20 extirpated. Only 225 species were considered to be endemic to Utah. The numbers are not comparable to those published in the Federal Registers due to consideration of species with broad distribution, a portion of which includes Utah, within the threatened and endangered categories. In later computations the number of endemic species is cited as 239 (Table 2). Welsh (1978) published a reevaluation of the endangered and threatened plants of Utah, in which some 53 species are regarded as endangered and 99 as threatened. Numbers in this latter publication are not comparable to those of the Federal Register lists due to deletions and additions.

That the biology of endangered and threatened species is that of restricted local endemics is found in the nonrandom distribution of those species. Utah can be divided into eleven phytogeographic subunits, each topographically, geologically, and phytologically different (Table 2). The numbers of endangered and threatened plants is approximately proportional to the number of endemic species in each phytogeographic subunit. Endemics constitute 27 percent of the total for the Navajo Basin; endangered and threatened plant species of that basin make up 28 percent of the total for the state. Proportions are similar for Plateau, Tavaputs, Uinta Basin, and all Other phytogeographical regions. Approximately 64 percent of all endemic species in these areas are considered as endangered or threatened. It is axiomatic that endemics should constitute the endangered and threatened candidates when the small areas occupied by them are considered.

Endangered and threatened species of the Navajo Basin and Plateau subunits constitute half of the total number for Utah. Other important regions include the Uinta Basin (13 percent), Great Basin (13 percent), and Mohave (14 percent). The remaining areas include only 11 percent of the species on candidate lists in total.

In general, endangered and threatened plant taxa in Utah occupy harsh substrates which are perceived by man as barren or nearly barren of vegetation. Hence, these critical species tend to occur in areas where there is little competition. Survival of the species depends on maintenance of the habitat in a condition wherein other species do not become competitive. Protection, as herein conceived, involves guarantees against man-caused destruction of habitat. Natural changes should not be treated as endangerment.

Phytogeographic Subunits and Endangered and Threatened Species

The distribution of critical species does not appear to be at random on the substrates available, and those substrates which support these species are not occupied uniformly. Rather, specific portions of apparently similar substrates are occupied, while others are not. Clays and other fine-textured colluvial or aeolian materials and limestones are the most commonly occupied substrates (Table 3). Together, they form the substrates of 81 percent

TABLE 2. Comparison of endemic, endangered, and threatened plant taxa by phytogeographic subdivision within Utah.

	Endemics		Endangered		Threatened		Total E & T	
Phytogeographic unit	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Colorado canyons	7	3			1	1	1	1
Navajo Basin	65	27	17	32	25	25	42	28
Plateau	48	20	11	21	22	22	33	22
Tavaputs	3	1	2	4			2	1
Uinta Basin	25	10	8	15	12	12	20	13
Uinta Mts.	4	2			4	4	4	3
Wyoming	3	1			2	2	2	1
Wasatch Mts.	23	10	1	2	6	6	7	5
Great Basin	35	15	7	13	13	13	20	13
Mohave	26	11	7	13	14	14	21	14
Pine Valley Mts.								
	239	100	53	100	99	99	152	101

TABLE 3. Endangered and threatened plant species arranged by substrate within Utah.

Substrate	Endangered		Threatened		Total	
	Number	Percent	Number	Percent	Number	Percent
Clay, silt, mud	27	41	31	31	58	38
Sand	9	17	28	28	37	24
Gravel			2	2	2	1
Igneous gravel			9	9	9	6
Limestone	9	15	21	21	29	19
Talus	1	2	1	1	2	1
Loam-humus	4	9	4	4	8	5
Water			1	1	1	1
Unknown	4	8	2	2	7	5
	53	101	99	99	152	100

of the taxa on critical lists. Water-washed alluvial deposits tend to support a greater plant cover than do the in situ substrates or those deposited by wind. Hence, probably because of the greater amount of cover and competition, the vast areas covered by waterborne alluvial deposits mainly lack critical species. The exceptions include some gravel deposits, especially those derived from igneous extrusive or intrusive stocks.

Critical species are present in several of the major vegetative types within the state. As with other criteria, the taxa are not randomly distributed in all of the plant communities. Pinyon-juniper, desert shrub, warm desert shrub, and salt desert shrub vegetative types bear 65 percent of all endangered and threatened candidates (Table 4). These are communities which lie within a low precipitation regime, wherein edaphic features are not insulated from plants by well-developed soil horizons or by organic matter within the soils. Edaphic features are the main controlling factors within low-elevation plant communities.

Even where plants of a critical nature are present within a community which tends to occupy most of the surface area, and where soils are well developed, thus preventing direct edaphic control, the endemic species are found mainly in clearings, along bluff margins, on ridge tops, and on other poorly vegetated micro-habitats.

Adiabatic and lapse rate differentials are reflected in elevational differences. High elevation areas are cooler and receive propor-

TABLE 4. Endangered and threatened plant species arranged by plant community (the plant communities in approximate order by elevation).

Community	Endangered		Threatened		Total	
	Number	Percent	Number	Percent	Number	Percent
Alpine			5	5	5	3
Spruce-fir	3	6	14	14	17	11
Aspen	2	4	1	1	3	2
Mountain brush	1	2	1	1	2	1
Ponderosa pine	2	4	7	7	9	6
Pinyon-juniper	17	32	27	27	44	29
Sagebrush	2	4	3	3	5	3
Desert shrub	12	23	4	4	16	11
Warm desert shrub	5	9	9	9	14	9
Salt desert shrub	4	8	22	22	26	17
Hanging garden			1	1	1	1
Aquatic			1	1	1	1
Other	1	1			1	1
Unknown	4	8	4	4	8	5
	53	101	99	99	152	100

tionally greater amounts of precipitation, resulting in production of mesophytic plant communities in those sites. Plant species of a critical nature are mainly xerophytes, regardless of the community type within which they occur. The large portion of species, some 60 percent of those designated as endangered or threatened, exist below the 6000 foot (1930 m) contour (Table 5). Possibly the reason for the great number of species at the lower elevations is due to the proportionally greater number of sites in arid lands which are open to colonization.

Chemical and water relations of substrates are closely allied to geological strata. Edaphic control by geological formations is greatest in areas where the strata are exposed. Layers of alluvium, which represent mixtures of materials from different sources, tend to insulate vegetation which grows on that alluvium from the chemical and water relations peculiarities of the individual stratum per se. Soil development reinforces separation of parent materials from plants. Hence, geological control of vegetative cover is greatest at lower elevations, where strata of many kinds are exposed over vast reaches. Soils as such are poorly developed or nonexistant due to low rainfall and the corollary lack of leaching of soluble salts.

There are regions at moderate to high elevations where edaphic factors of geological strata are controlling due to peculiarities of topography and geomorphology. Cliff faces and breaks at the margins of plateaus and ridge crests are examples of such places. In others, substrates which are very acidic or basic, as in some igneous or limestone strata, tend not to be insulated due to lack of growth of dense vegetation. Plant species of a critical nature occur on a series of geological strata ranging in age from Quaternary to Precambrian (Table 6).

There does not appear to be any particular stratum which bears a disproportionately large number of endangered or threatened species. The largest number is found on Quaternary alluvia, mainly on dunes or stabilized dune sand and on residual accumulations on the formations from which they were produced. Even this small number represents only 17 percent of the included species. Dunes are open habitats. They are mesophytic sites in otherwise arid lands. They represent an anomaly wherein competition is low, but where water is relatively abundant and available.

If mudstone, siltstone, and shale strata are considered collectively, some 37 percent of the species reside on them. Limestone or other highly calciferous formations, such as Flagstaff, Wasatch, and the Carboniferous strata, provide substrates for 17 percent of the total plant species. Sandstone and conglomeritic formations account for only 10 percent of the taxa.

Partitioning of the phytogeographic subdivisions demonstrates differences and similarities in areas of distribution, and in the control of that distribution. Disparity in geological strata is obvious from one subunit to the next, and potential substrates differ because of the different kinds of strata available. The Paleozoic strata of the Great Basin and of the Wasatch Mountains present an entirely different array than do the Uinta Mountains, Uinta Basin, Navajo Basin, and Mohave subunits. Plant communities reflect those substrate differences, often in subtle ways. Additionally, the phytogeographic subunits are topographic features whose definitions are tied to elevation.

Despite the problems associated with comparison, and the obvious differences—which should not require discussion—an analysis of the various phytogeographic subunits will be

TABLE 5. Endangered and threatened plant species arranged by elevation stratification.

Elevation	Endangered		Threatened		Total	
	Number	Percent	Number	Percent	Number	Percent
<6000 feet (1830 m)	34	64	58	58	92	61
6000–9000 feet (1830–2745 m)	13	24	30	30	43	28
>9000 feet (2745 m)	3	6	10	10	13	9
Unknown	3	6	1	1	4	3
	53	100	99	99	152	100

instructive in attempts at management of lands in the respective areas as regards endangered and threatened species. The total numbers of species in a given subunit might be indicative of trends (Tables 7, 8, 9, and 10).

Summaries of species number and percentages for substrates in each of the phytographic subunits demonstrates similarities between the Navajo Basin, Uinta Basin, and Mohave subunits (Table 7). In each of these, clay, mud, silt, and sand constitute the substrates of more than 85 percent of all critical plant species. Plateau subunit differs in bearing more than 50 percent of the included species on limestone, and with igneous gravels being second with 18 percent. Patterns in the Great Basin are obscure, with no single substrate supporting more than 25 percent of the species. Six of the seven species from the Wasatch Mountains are known from limestone. The other phytogeographic subunits bear so few species as to not demonstrate trends.

When plant communities are compared for each of the phytogeographic subunits, it is clear that pinyon-juniper and the various kinds of desert shrub communities support most of the endangered and threatened plant species in the Navajo Basin, Uinta Basin, and Mohave subunits in Utah (Table 8). Spruce-fir, ponderosa pine, and pinyon-juniper communities are the sites of occurrence of some 71 percent of the critical species in the Plateau subunit. Alpine and spruce-fir are the main communities of those species in the Uinta and Wasatch mountains.

The Navajo, Uinta, Great Basin, and the Mohave subunits bear 80 to 100 percent of the species below 6000 feet in elevation. In Plateau, Tavaputs, Uinta Mountains, and Wasatch Mountains all species are above the

TABLE 6. Geological strata as substrates of endangered and threatened Utah plant species (Note: species were assigned to only one stratum, the major one, even if they occurred on more than one. Strata without numbers of species, indicated by a dash, are known to support critical species; those not marked are not known to support them.)

	Threatened		Endangered		Total	
Strata	Number	Percent	Number	Percent	Number	Percent
Quaternary	18	18	8	15	26	17
Flagstaff			2	4	2	1
Green River	3	3	10	19	13	8
Bald Knoll	—	—	—	—		
Wasatch	9	9	4	8	13	8
Duchesne River	5	5			5	3
Tertiary Igneous	9	9	1	2	10	7
Kaiparowits	2	2			2	1
Wahweap	—	—				
Straight Cliffs	1	1			1	1
Mancos Shale	5	5	4	8	9	6
Tropic Shale	1	1	2	4	3	2
Mowry	1	1			1	1
Arapien	4	4			4	3
Cedar Mt.	1	1			1	1
Morrison	—	—	1	2	1	1
Entrada	2	2	1	2	3	2
Carmel	1	1	3	6	4	3
Navajo	5	5	3	6	8	5
Wingate	—	—				
Chinle	1	1			1	1
Moenkopi	7	7	5	9	12	8
Cutler	1	1	1	2	2	1
Cedar Mesa	1	1	1	2	2	1
Paradox	—	—				
Carboniferous	12	12	1	2	13	8
Precambrian	3	3			3	2
Unknown	7	7	4	8	12	8
	99	99	53	99	152	99

TABLE 7. Substrates of endangered and threatened plant species by phytogeographic subdivision in Utah.

	Colorado Canyons		Navajo Basin		Plateau		Uinta Basin	
Substrate	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Clay, silt, mud			23	55	2	6	16	80
Sand	1	100	16	38	4	12	3	15
Gravel							1	5
Igneous gravel			11	2	6	18		
Limestone					17	52		
Talus			1	2				
Loam-humus			1	2	2	4		
Water					1	3		
Unknown					1	3		
TOTAL	1	100	42	99	33	98	20	100

6000-foot contour (Table 9). Part of the explanation for this correlation is based on the definition of the subunits. The basins are mainly below 6000 feet in elevation, and the mountains are mainly above that figure.

Similarities of geological formations in chemical and physical structure seem to be more important than the geological strata by themselves. Cutler, Moenkopi, Chinle, Carmel, phases of the Entrada, Morrison, Arapien, Tropic Shale, Mancos Shale, and Duchesne River formations tend to resemble each other texturally, and in having high amounts of soluble salts. Each of these support one or more of the endangered or threatened species, some of which might be expected on others of those formations also. Indeed, some do occur on more than one formation, even though Table 10 is presented with only the major formation that serves as substrate represented. Differences and similarities between the subunits of the state are obvious. Geological strata in subunits of the Colorado drainage system tend to be most similar, but even in those there is a tendency for plants to react differentially, despite the similarities of stratigraphy.

PREDICTIVE CAPABILITY

Because of the nonrandom distribution of narrowly restricted species in Utah, it is possible to prepare a model with predictive capability which will aid in the search for these critical plants. The model, a sample of which is presented in Table 11, is based on deduc-

TABLE 8. Plant communities of endangered and threatened plant species by phytogeographic subdivision in Utah.

	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
Plant Comm.	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Alpine			1	2	2	6		
Spruce-fir					9	27		
Aspen					1	3		
Mountain Brush							2	100
Ponderosa pine			2	5	8	24		
Pinyon-juniper			18	44	6	18		
Sagebrush			1	2	4	12		
Desert shrub								
Warm desert shrub			6	15				
Salt desert shrub			12	29				
Hanging garden	1	100						
Aquatic					1	3		
Other					1	3		
Unknown			1	2	1	3		
	1	100	41	99	33	99	2	100

TABLE 7 continued.

Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave		Tavaputs	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
						5	25	9	43	2	100
		2	100			4	20	9	43		
						2	10				
						1	5				
				6	86	5	25	2	10		
1	25										
3	75					1	5				
				1	14	2	10	1	5		
4	100	2	100	7	100	20	100	21	101	2	100

tions derived from the nature of the distribution of those species evaluated above. The reasoning behind the model is based on the unequal occurrence of the species with regard to several parameters. The probability of occurrence is determined by use of a numerically weighted system in which the parameters are given a value of zero, one, or two as indicated by the known presence of the species on specific portions of the state. For example, most of the species of restricted plants occur on the finely textured soils, the next highest proportion on dunes, in situ sand, and limestone, and the lowest on soils consisting of gravel, talus, loam, and humus. Hence, these substrate types are rated as two, one, and zero, respectively.

The example outlined in Table 11 is suggested for the state, but more finely partitioned models are suggested for each of the phytogeographic subunits. It would not be logical to apply a high numerical weighting to elevations below 6000 feet for areas within the Plateau phytogeographic subunit where practically all the known critically restricted plants are above that elevation.

Despite the usefulness of the suggested model, and its modifications, it is suggested that the model should be used as a planning tool only. There is no substitute for on-ground inspection and the collection of the general flora to provide information on actual presence of plant species. Wherever possible such on-site investigations should provide herbarium materials for deposit in herbaria, taken in such manner as not to con-

TABLE 8 continued.

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
		3	60			1	14				
		1	20			5	71				
		1	20			1	14	1	5		
										1	5
8	40			1	50			3	15	7	33
9	45							10	50		
										2	10
3	15							4	20	9	43
				1	50			2	10	2	10
20	100	7	100	2	100	7	99	20	100	21	101

TABLE 9. Elevation of endangered and threatened plant species by phytogeographic subdivision in Utah.

Elevation	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<6000 ft.	1	100	33	80				
6000–9000 ft			7	17	24	73	2	100
>9000 ft.			1	2	8	24		
Unknown					1	3		
	1	100	41	99	33	100	2	100

stitute a threat in and of itself. This will guarantee that information gained in field surveys will not be lost in the files of agencies and industries attempting to work on the lands of the state.

Perspective on the Endangered Species Act

Value judgements as to the role of plants of limited distribution have not stopped, slowed down, or even modified the course of human expansion through all of history until now. The present society has asked whether plant species should be eradicated as a part of the common good of our civilization. Value is a time-oriented function; that considered as valueless today might be judged as very valuable in the future. Numerous examples of minerals are known which support this observation. Plants have been surveyed many

TABLE 10. Geologic strata serving as substrates of threatened plant species by phytogeographic subdivision in

Strata	Colorado Canyons		Navajo Basin		Plateau		Tavaputs	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Quaternary			4	10	3	9		
Flagstaff					2	6		
Green River							2	100
Bald Knoll								
Duchesne R.								
Wasatch					14	42		
Tertiary			2	5	7	21		
Kaiparowits					2	6		
Wahweap								
Straight Cliffs			1	2				
Mancos			8	20				
Tropic			3	67				
Dakota			1	2				
Mowry								
Arapien								
Cedar Mt.			1	2				
Morrison			1	2				
Entrada			3	7				
Carmel			3	7	1	3		
Navajo	1	100	4	10	2	6		
Wingate								
Chinle								
Moenkopi			3	7				
Cutler			2	5				
Cedar Mesa			2	5				
Paradox								
Carboniferous								
Precambrian								
Unknown			3	7	2	6		
	1	100	41	98	33	99	2	100

TABLE 9 continued.

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
20	100			1	50			17	85	19	90
		2	40			5	71	1	5	2	10
		3	60			2	29				
				1	50			2	10		
20	100	5	100	2	100	7	100	20	100	21	100

times for sources of biologically active materials, e.g., alkaloids, vitamins, hormones, wonder drugs, and cortical steroids. Now they are again being surveyed for antitumor agents. Common plants are being surveyed first, primarily because of their ready availability. The rare plants will be reviewed as material becomes available. It would be a tragic irony if the best anticarcinogenic agent should be discovered in the leaves of a herbarium specimen of a species which had just become extinct.

Extinction occurs as a function of natural forces, or as a function of man-caused factors. The former is selective in reducing populations of living things. The latter is nonselective.

The reasons for extinction of narrowly restricted plants on the same outcrop might involve loss of a pollinator for one species, in-

TABLE 10 continued.

Utah (Note: Only the major formation is indicated where plants occupy more than one.)

Uinta Basin		Uinta Mts.		Wyoming		Wasatch Mts.		Great Basin		Mohave	
Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
3	15					1	14	7	35	7	33
10	50										
4	20										
								1	5		
1	5										
								4	20		
1	5										
1	5										
										2	10
										2	10
										7	33
						5	71	5	25	2	10
		4	80								
		1	20	2	100	1	14	3	15	1	5
20	100	5	100	2	100	7	99	20	100	21	101

festation by insects or disease for another. A construction project might cause wholesale extirpation by removal of the entire community. The rate of man-caused extinction far exceeds the natural rate. Thus, extinction caused by man is not a part of the natural scheme.

The Endangered Species Act of 1973 made it possible for future generations to be involved in the value-oriented decisions. The act provides an advocate for generations yet unborn.

Genetic pathways are, despite all of the possibilities, essentially one-way streets. The route by which a species is formed is as important as the end result. The reconstitution of the pathway requires the same criteria as were present in the past, a functional impossibility to recreate. Thus, the loss of any species terminates a line which cannot be reformed. And, once gone, the question of value to mankind is deprived of practical significance.

The reason most of the proposed endangered and threatened plants are considered thusly is because the known populations are small and exist in very limited areas. Average distributional densities of one endangered species to each two or three thousand square kilometers, and of threatened species to values of roughly half that figure, give an approximation of their true paucity. Further, only a very small part of the total land surface is involved.

Distribution of rare species is not equal, as has been discussed above. Certain areas appear to lack them altogether, while other areas support concentrations of several species. Unless a specific mineral to be exploited is located within one outcrop which supports one or more species, or unless the area to be occupied by a particular development is large, there is no reason why modern expansion should impress any of the currently known endangered or threatened species. Even in these two exceptional instances there is no real reason to displace indigenous endangered and threatened species; the best site for industrial development is not always the only good alternative.

Thus, if developers, and if the governmental agencies which control development on federal lands, follow the requirements as set forth in the act, there is little question that many, if not all, of the plant species which are ultimately determined as endangered or threatened can persist in perpetuity. The question of value of these plants is not an issue; the areas occupied by these plants can be avoided.

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TABLE 11. Outline of a predictive model for establishing priority areas for study of endangered and threatened plants of Utah.

Numerical weighting	Substrate	Community	Elevation	Geology	Phyto Subunit
0	Gravel, talus, loam, humus	Other	9000	Other	Colorado Canyons, Wyoming, Pine Valley
1	Dunes, in situ sand, limestone	Spruce-fir Ponderosa	6000–9000	Sandstone, in situ sand and limestone	Wasatch Mts., Uinta Mts., Tavaputs Pl., Plateau
2	Clay, silt, mud	Pj-Des Sh variations	6000	Shale mud and siltstone	Navajo, Uinta, Mohave, Great Basin